EXPERIMENTAL RESEARCHES,

ILLUSTRATIVE OF THE

FUNCTIONAL ONENESS, UNITY, AND DIFFUSION,

OF NERVOUS ACTION;

IN OPPOSITION TO THE

ANATOMICAL ASSUMPTION,

OF FOUR SETS OF NERVES, AND A FOURFOLD SET OF

FUNCTIONS, AND TRANSMITTED IMPRESSIONS;

WITH A BRIEF EXPOSITION OF THE

PHILOSOPHY OF VIVISECTION, AND OF SENSATION.

BY

BENNET DOWLER, M. D.,

OF NEW-ORLEANS,

Corresponding Member of the Academy of Natural Sciences of Philadelphia; Member of the American Medical Association, and its Chairman of the Committee of the Medical Sciences for 1850–1*; Member of the Medico-Chirurgical College of Philadelphia &c.*

"What truth so ever is necessary, and of universal extent, is derived to the mind from its own operation," [as the infinity of space, and of duration] "and does not rest on observation and experience; as, conversely, what truth or perception is present to the mind, with a consciousness, not of its necessity, but of its contingency, is ascribable not to the original agency of the mind itself, but derives its origin from observation and experience."

KANT'S METAPHYSIC. (*Trans. by* MR. SEMPLE, *Edin.*)

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EXPERIMENTAL RESEARCHES, ILLUSTRATIVE OF THE FUNCTIONAL ONENESS, UNITY, AND DIFFUSION, OF NERVOUS ACTION; IN OPPOSITION TO THE ANATOMICAL ASSUMPTION, OF FOUR SETS OF NERVES, AND A FOURFOLD SET OF FUNCTIONS, AND TRANSMITTED IMPRESSIONS; WITH A BRIEF EXPOSITION OF THE PHILOSOPHY OF VIVISECTION, AND OF SENSATION.

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The Reflex Theory of the Spinal Cord, implied in the title of this essay, will not now be scrutinized; nor will many new experiments, recently made, in this department of Physiology, be detailed in this paper. The reader is referred to former publications, in which, for nearly ten years, I have been occasionally engaged in the examination of this theory.

Before proceeding to the main objects of the present investigation, it is necessary to glance at existing doctrines in this department of Physiology.

Dr. Dunglison, in the last edition of his very valuable work on Physiology, (I, 100,) sums up the anatomy of the nervous system by virtually asserting, that there are four distinct sets of nerves—namely: 1st, the *sensory;* 2d, *motory*, connected with the brain by tracts; 3d, the *excitor*, and 4th, the *motor* of the spinal marrow. Although this is a fair enumeration of the existing doctrines of those called "distinguished physiologists," yet this enumeration is entirely hypothetical. In what code of morality do "distinguished physiologists" get a warrant to assert, as physical or anatomical facts, that which no one has ever seen—no one has ever demonstrated? Have "the most distinguished" any better right than other people, to assert that man has four heads, hearts or noses? If, for instance, there be two distinct sets of nerves for the excito-motory function of the spinal cord, wholly independent of the brain, why not show them to the sceptical? Is there no difference between a name, and a thing? Is a mere opinion, the same as material anatomy? Can any amount of theoretical lore be received as valid proof, that there are four railways at this moment between Maine and California?

The only anatomical proof yet offered, is this—namely—the nerves have double roots; and, hence, it is said, must have double offices! Here, the facts and the conclusions have no known connection. The Biceps muscle has two heads—some teeth have two roots; must these, therefore, have, of neccessity, two distinct functions?

The double sets of nerves constituting the excito-motory system,—which are said to be physical in their nature—reflex in their action—the one set to conduct impressions down into the "true cord," the other to reflect these outwardly upon the muscles—all being independent of the brain, sensation, and volition,—are wholly hypothetical, and without anatomical reality. This piece of anatomy rests wholly on the solemn and persevering declarations of its advocates, whose language, in 1846, I characterized as jargon, and which, now, in 1851, might justly be regarded as bordering on insanity. Is it not strange, that writers spend months and years in teaching and writing on this branch of anatomy, when, in five minutes, with a knife, they might demonstrate the four separate and distinct sets of nerves, instead of making so many books filled with words of the most unintelligible coinage, as the nerves termed "diastaltic, esodic, exodic, anodic, cathodic, paltodic, panthodic, anastaltic, catastaltic, peristaltic," *ad infinitum*—all having originated within one year. Nothing provokes the ire of certain critics in this country, so desperately, as to question this sort of anatomy. Their invariable answer to all dissenters is not that of experiment and demonstration, but that of certain "distinguished physiologists" in some distant land, whom they follow.

The largest liberty of thought and opinion is allowable in the theories of the nervous functions; but in anatomy, as well as in geography, facts alone must constitute the basis of description. Sensation and motion are as devoid of anatomical structure, as virtue and vice, gravitation and cohesion. Anatomy is concrete, not abstract; physical, not functional. The white, fibrous and the grey vesicular matter of the nervous system, are physical facts, be their functions what they may. Weight is a function or property of matter. What would be thought of an engineer who would attempt to give topographical descriptions, diagrams, and maps of ponderosity? It is a fundamental error in physiology, as well as in anatomy, to ascribe a function to an unknown organ, in order to prove, by this assumption, the anatomy of the organ itself. Beautiful are the engravings in books of physiology, illustrating this kind of anatomy, taken from nature!

Were four sets of nerves demonstrated, even microscopically,* as anatomical facts, still it would not follow that they must necessarily

*Professor R. B. Todd, in his late work on the brain, cord, and ganglions, admits, that the microscropical appearances of the nerves, "afford *no certain* indication of the course and direction of the nerve-fibres, nor of the situation of the finer elements of the vesicular matter. Microscopic investigation has, as yet, thrown no light on the *direction* and *connections* of the fibres of the cerebrum and cerebellum."—270, 274.

have an equal number of separate and independent functions; for, it might happen, that their functions would be identical, that is, all might be (probably are) sensory—not two of them motory, as they are assumed to be,) seeing that the muscles possess, beyond question, an inherent force, and consequently motion, peculiar to themselves.

These topics will be resumed after having given the experimental portion of this investigation.

Alligators A and B, with several others confined in the same enclosure, had, for several months, lived together in the utmost harmony. When they basked in the sun, or slept, they placed their bodies, limbs, and heads so as to touch or rest on one another. Under circumstances calculated to produce angry feelings among animals, as when they entered the water where they were much crowded, and when they were fed, fighting never took place, until the 2d of August, 1850; at which time, while feeding them, I discovered that A, the largest of the four, and B, the next in size, were no longer friends. The former exceeded five feet in length, and was very stout and strong; the latter was nearly as long, but less muscular. A, C, and D ate chicken and fresh beef voraciously, without contention, while B stood off for some time, but ventured at length into the water, where the bait was thrown, and, having seized a portion, ran quickly into a corner to swallow his food. Soon after he returned, whereupon A jumped at him with expanded jaws, and bit him across the middle of the body and tail. A fight ensued. I interfered, and beat A with a pole, so that he was obliged to quit the combat. Having concealed myself, I watched A through an opening in the wall of the den, whereupon he renewed the fight. I again interfered, but he renewed the attack repeatedly, and as soon as I concealed myself. Finally, B ceased to resist. His whole attention, and apparently, his last hopes, centred upon making good his escape from the pen. He forthwith attempted to climb a perpendicular brick wall, but instantly fell back. He then appeared to survey the den, and, having selected with the greatest judgement the only portion of it where an escape was possible, he pressed his body between a post and the brick wall, fixing his claws in the crevices of the plank fence, he mounted to the top and was about to throw himself on the outside of it, when I gave him a blow that caused him to fall back again. As if in utter despair, he stretched himself out, and howled most pitiously—a peculiar, but expressive and indescribable wail. The day was far advanced, and business interfered, yet I was obliged to vivisect him, in order to save him from a more cruel death by his enraged and more powerful associate. His defeat by the latter, and his struggles with

myself in capturing him, together with a high temperature of the weather, doubtlessly modified the results of the vivisection that followed.

The copious hemorrhage which succeeded decapitation, was not arrested by ligature, or by other means. Life was extinguished in a much shorter time than usual. The persistence of life in this animal, after decapitation, is almost in an inverse ratio to the heat of the weather; at least it is so to a considerable extent, being dissipated much more rapidly in the summer than in the spring or winter. The head died first—that is to say, sensational, volitional, and motory phenomena disappeared from the head in five minutes; while in the trunk, these were manifested, when tests were used, during an hour, not to mention minor vestiges of vitality which continued as long as the experiments—a period of five hours, spent in extensive dissections, and progressive mutilations.

The first division of the animal, that is, decapitation, took place near the shoulders, after which, for several minutes, the mouth gasped, and attempted to bite; the eyes soon closed, and with increased force when the lids were touched. The headless trunk (as upon many former occasions) performed numerous actions indicative of sensation, intelligence, and volition. Resting perfectly quiet, deprived of all the special senses, it possessed only the general sense of touch, which responded in an accurate manner to all tactual impressions, even the simplest. No active agent, no pricking, no fire, was required to elicit definite and combined motions. The slightest touch of the finger seemed to be perceived by the whole trunk—the tail and limbs, as proved by their motions. The animal seemed to be aware of the nature of the touching body, which, if free from a pain-giving property, was borne without any violent efforts to escape from it; but fire, punctures, and skining, called into agonized action, the body, limbs, and tail. The body curved in a manner so as to recede from the offending agent; the limbs were directed so as to remove it, and even the short stump of the headless neck was turned in the proper direction as if to bite, as if forgetful that it had lost its head. The organs of smelling, tasting, hearing, and seeing having been completely lost, and its locomotive power greatly impaired, it appeared to concentrate its attention on the only remaining sense—touch; and, from its action, far more impressive than words, it was evident that it judged accurately as to the nature, degree, duration, and place of painful, or painless impressions.

Hitherto, from reading, as well as from my own numerous experiments, I had drawn the conclusion, that a decapitated animal was incapable of forward, linear motion. This I found to be quite erroneous.

I had, as far as I can recollect, always applied the irritant to the limbs, or to the sides, but not exactly perpendicularly over the spine. The animals, as I now believe, had always perceived this, since they had always acted accordingly—as they had always curved their bodies laterally, sometimes they had rolled quite over, always from, never towards, the pain-producing agent. I found, on applying a lighted match perpendicularly over the spine, that the animal went straight forward. It would have crawled off the table had I not prevented it, by returning it to its original position. This experiment was several times repeated, and always with the same results; which seem quite sufficient to establish the principle of possible forward voluntary motion after decapitation—being so simple and satisfactory as not to allow of mistake, while they show, at the same time, the accuracy with which the headless animal perceives and judges of the exact locality of an irritant. All of which may be inferred from the intelligent motions described.

The next step of the vivisection, following decapitation, consisted in the division of the spine, including many muscles, at a point about one fourth of the distance from the hips to the shoulders. This diminished the activity of the trunk, but did not wholly prevent the mutual and simultaneous actions of the two divisions, in warding off injuries of either; thus, when a bit of burning paper was applied to the flanks, the fore legs were directed strongly to the seat of the pain, and in a straight line (that is, in the utmost degree of extension,) along the sides of the body, without any lateral flexure common to the trunk and tail, as seen before the second division, though the tail, hind legs, and body, as far as the division of the spine, continued to act in concert with the fore-legs. The division of the spine, together with the dorsal and cervical muscles, accounts for the absence of motion in the anterior half of the trunk. After decapitation, and even subsequent to the second division, the animal several times uttered a kind of guttural sounds, which were, at the time, attributed to the mere mechanical effects of the experiments, causing the expulsion of the air from the lungs, through the divided trachea. But it was soon ascertained, that several irregular respirations took place—irregular as to the times. Breathing, however, actually continued thirty minutes, by estimation.

For about one hour, both divisions of the body gave proof of sensibility and voluntary motion; that is to say, the fore-legs, the hind-legs, and the tail, were directed forwards, backwards, and upwards, and laterally, so as to avoid or remove (as it sometimes did,) an irritant. As the pain-giving agent was varied in its degree, and in place, so were

the animal's actions directed understandingly, and with a violence responding to the intensity of the pain or irritation—actions in no degree assimilating the involuntary, automatical, and mechanical.

The course of the next experiment was directed to the left hind-leg. The sciatic nerve was exposed as near its origins as possible. At first, the animal manifested considerable resistance. It attempted to withdraw its limb. In the meantime, the opposite limb and the tail moved in a lively yet consentaneous manner, as if conscious of suffering. The nerve was firmly tied. This caused the limb to twitch. These twitchings were renewed at pleasure, by pinching the nerve on the distal side of the ligature. The nerve was divided, but pinching produced identical results. Sometimes the motion was in the flexor, sometimes in the extensor direction. At first this appeared unaccountable, but on prosecuting the dissection towards the peripheral distribution of the nerves, the sciatic was found to consist of two principal trunks, which, in the popliteal region, diverged—the one to the extensor, and the other to the flexor sides of the leg. When separately pinched, these cords produced twitching oscillations, approximating extension and flexion, giving the feet and toes a motion of one or two inches, in the direction accordant to their ultimate distribution in the muscles. When these two cords were experimented on in the thigh, (where they lie together,) it is supposed that the forceps sometimes compressed one more than the other, thereby causing corresponding flexor, or extensor twitchings—a supposition which was confirmed by separating these nerves, and compressing each one by itself. The motions increased, on following the nerve towards its distribution. One or two twitches were elicited once or twice in a second, the limb always returning to its original position or equilibrium.

A violent or disorganizing crush did not often produce a greater motion than a moderate compression, but prevented all subsequent motions when the same part was pinched again in the same place, though the part adjoining on the distal side, retained its motory function unimpaired. A moderate, continuous compression produced many motions, which, after a time, ceased, but which, after an interval of rest, were generally renewable.

The limb was skinned, the principal nerves were removed, and the muscles insulated from each other, though they were still attached to their origins and insertions. It was found that compression of the latter, produced twitchings similar or rather identical with those from pinching the nerves. The removal of every visible nervous twig, did not influence these muscular motions.

Two hours after decapitation, and nearly an hour after the second division, the spinal canal was longitudinally opened, from the transverse division, to a point of the caudal spine, beyond that which gives off the nerves to the hind legs. Upon touching the posterior and anterior roots of the nerves belonging to the dissected limb, tbe gluteii muscles and the adductors of the thigh twitched, but the limb and the more distant muscles were motionless, while the opposite unmutilated leg twitched everywhere, without, however, any motion of the entire limb, except near its extremity, chiefly in the ankle and toes. Touching the cord, or either root of the nerves, produced only three or four feeble motions. But as the dissection progressed from the centre to the circumference, these motions augmented in number, duration and extent, even after amputation and the isolation of the nerves, and after extensive destruction of their proximal portions. The muscles separated from the nerves, and from contact with each other, contracted from puncture or compression, just as in the case of the nerves themselves.

The next experiment, (more than three hours after decapitation,) consisted in passing a rod into the cervical portion of the spinal canal, so as to destroy the cord two or three inches below the part giving off the axillary plexus. This produced only two or three faint twitchings in both of the fore-legs. One leg was amputated, the other remained attached—both were dissected with results identical with those obtained in the hind-legs.

1850, July 31st; 8 A. M. Air of the room 80°; open air 81½°; gullet of the alligator, 81½°. The spine and adjacent muscles were divided between the shoulders and hips. The animal's actions, both above and below the division, were vigorous, and were, in both parts, sometimes mutually directed to a common end; as in the avoidance or removal of a lighted match, and the like. After the division, it was found necessary to tie the animal for twenty or thirty minutes. The hemorrhage was great: probably the great abdominal artery had been divided, as the cavity of the chest had been opened in cutting through the spine and soft parts; for, on immersing the animal in a tub of water, with a view of washing the skin, which was muddy, the water filled the cavity. This appeared to cause the animal's death in a very few minutes; that is, all voluntary motion, and sensation, as tested by fire, punctures, &c., &c., ceased.

The dissection, which was confined for the most part to the nerves of the limbs, lasted five hours; during which time, the same motory phenomena were elicited as in the preceding experiments.

A ligature was firmly tied around the sciatic nerve, which caused a

twitch ; pinching on the proximal side, produced no effect, below motion. Another ligature placed half an inch from the first, on its distal side, caused a movement as did the first. Pinching between the ligatures produced no apparent effect ; while below, it caused motion, as usual. In the popliteal region, as already described, the nerve is double—one stran passing directly on, but soon dividing into two trunks on the lower side of the leg ; the other goes to the opposite side, dividing in like manner. On pinching both of these cords on one side, all the toes twitched in one direction ; on pinching one cord only, two toes moved, and on pinching the other cord, the remaining two did the same. On the opposite side of the limb similar phenomena occurred, but the motions were in a contrary direction. In both cases the momenta augmented, (at least in the toes,) as the irritant approached them. The muscles, deprived of such nerves as were visible, twitched as in the former case, with undiminished force. The sciatic nerve and its branches in the left leg, were successively crushed or cut away, down to the instep and sole ; each new part that was crushed, produced one motion, which never could be renewed by pressure in the same place. This dissection of the left leg, lasted an hour and a half.

The spinal canal, corresponding to the lumbar and sacral portions in the human subject, was opened. On pinching the posterior or anterior roots of the nerves passing to the right, or unmutilated leg, three or four slight twitchings took place in the muscles, ceasing almost immediately, nor could they be reproduced by even dissection and removal of the cord. The limb was amputated at the hip ; the skin removed ; the nerves and muscles dissected in the downward direction. The motory phenomena from the compression of the nerves and muscles, appeared more distinct than those previously manifested in the left limb.

1851, Jan. 27th ; 10 A. M. Air, 64½° ; pharynx of the alligator (chosen for the following experiments,) 65° ; air of the room, 68°. Length of the animal, nearly three feet ; circumference, about fifteen inches. It had been several times, during the coldest days of winter, nearly torpid, but was, at the time of the vivisection, active. It was firmly bandaged to a narrow plank, with the exception of that part of the lumbar and caudal spine which was the site of the first experiment. The dissecting required deep cuttings to reach the spine. It was found necessary to make vertical sections on both sides of the spinous processes of the vertebræ, in order to remove the skin and muscles, and thereby to open a deep furrow for the double purpose of making room for the saw, and for the sight. The bleeding was profuse and prolonged.

The indications of pain were very marked, particularly in dividing the skin, and in operations on the spinal marrow. The dissections at these points gave rise to violent struggles, and plaintive sounds, which were not elicited by cutting the intervening tissues. Before the canal was opened, the muscles of the hind-legs appeared considerably paralysed, flaccid, and altered, having assumed a different position, causing the thigh to appear flattened, though a few irregular and violent motions of both limbs took place on irritation of the nerve-roots. After much difficult and careful manipulation, the spinal theca (which is black,) was exposed, apparently uninjured. The hind-legs were motionless. Touching the cord, or either spinal root, caused the animal to moan, and struggle a few times. On tracing and touching the spinal roots, after the cord was removed, extremely slight twitchings were produced, which almost immediately ceased. The consistence of the cord is extremely soft. A slight pressure disorganizes the cord and spinal roots completely, though the nerves, beyond the limits of the spinal canal, possess considerable firmness and strength.

After the cord had been removed, some of the roots were traced still further in their passage outwards; these, on being pinched, produced a few slight twitchings in the muscles of the corresponding limb. For a considerable period, the dissection was confined to one leg, which was skinned, and its nerves and muscles traced. The results were precisely such as have been already detailed. The twitchings increased on following the nerves towards the periphery; crushing produced one or two movements only; these, however, were sometimes greater than those from slighter compressions. By seizing the two principal trunks on the upper, or the two on the lower side of the limb, the foot and toes could be made to oscillate to and fro, according as the one or the other set were manipulated; or, by using only one stran out of the two on each side, two toes only were set in motion. The destruction of the nerves did not impair the force of the muscular twitchings from puncture and pressure, as already described. In the meanwhile the indicants of a double life, a double sensation, and a double volition, continued in the tail below, and in the body above, that portion of the cord that had been removed—the one independent of the other. The pupil of the eyes had dilated slightly, though they responded to the degree of light. The superior plate of the skull was removed, together with the cerebellum. After the division of the olfactory and optic nerves, the pupil expanded permanently; yet, the eyelids continued to wink. The removal of the brain did not appear to cause pain, so far as motion is an indication of pain, until the operation approached the cerebellum.

The cutting of nerves at their origin, and the removal of the cerebellum and oblongata, appeared to cause great agony. The struggles were violent, but transient. The caudal portion of the animal remained unaffected by the operations upon the head. As the animal was now unable to escape, the bandages were removed; the tail, the body, and the fore-legs, tested by irritants, appeared to manifest feeling and volition, both above and below the division, though not in unison. The legs and tail showed contrivance and design, in the removal or avoidance of fire, &c. The animal was placed on its back; a portion of the sympathetic nerve was dissected, and the viscera, examined *in situ*. The lungs were several times artificially inflated. After the removal of the brain, and the medulla oblongata, the power of directing the fore-legs in a voluntary manner, gradually declined, and at the end of two hours, ceased altogether. A probe was passed from the original opening in the spine, two or three inches down the caudal canal, without producing any motion. But the lower half of the tail was still directed in an intelligential manner. Thus, if a piece of ignited paper approached its right side, it swayed itself to the left, and so of the contrary. The dissection now returned to one of the hind-legs that had not yet been mutilated. The motory phenomena continued as before described. At the end of the seventh hour, when the experiments ended for the day, the tail alone indicated voluntary motion, in the last five or six terminal inches. The tip swept to and fro, so as to avoid fire, &c. The heart was still beating.

Jan. 28th; 10 A. M. Same animal.—The hind-legs and the entire tail were still flexible. The neck, body, and fore-legs, together with both ventricles of the heart, were rigid. The right auricle still contracted—sometimes spontaneously—always when touched. In the hind-legs, the motory phenomena, in such parts as had not been completely disorganized, were active; sometimes, more so than at the close of the previous day. Muscles that had been apparently exhausted, and deprived of their nerves, twitched on being punctured with a pointed probe; or, when pressed between the thumb and fingers, assumed a lumpy, hard form, moving the entire limb.

The fore-legs, (rigid, as above mentioned,) were, by means of repeated forcible flexions, and extensions, made quite supple—and were afterwards dissected:—motory phenomena were observed in these limbs, as well as in those that had not been yet invaded by the *rigor mortis*, but in a diminished degree. These experiments lasted seven hours.

Jan. 29th; 10 A. M. Same animal.—Rigidity had reappeared in the fore-legs, and had, for the first time, invaded the hind-legs, and the tail,

excepting two or three inches at its termination. The tail, (except its tip,) had, in becoming rigid, assumed a curved form; owing, it is supposed, to a partial dissection of its muscles on one side, made on the preceding day, whereby the muscular equilibrium had been destroyed. The convexity, accordingly, presented itself on the side that had undergone mutilation. The site of the spinal vivisection had assumed an injected, vividly red appearance. The gall-bladder, which had been from the first, distended to its utmost capacity, remained unchanged—not having lost any of its bile by exosmosis, or transudation. The intestines were removed, opened, and examined. Their cut edges assumed irregular forms, and even retracted, so that their margins almost met; causing the mucous membrane to appear, in a great degree, as the external surface. The arteries were empty—the cavas distended with dark blood, none of which had yet transuded. The limbs were made supple artificially, (as had been done formerly,) but on being left undisturbed for one or two hours, they became rigid again. The experiments lasted seven hours, at the end of which time, no indications of vitality were apparent.

Decapitation has great advantages over the usual method of stunning an animal by a blow on the occiput, preparatory to vivisection—an advantage which seems to have been overlooked in solving the problem, whether the brain be the exclusive seat of sensational cognition. A stunning blow, to destroy sensibility, is but an equivocal proof of the destruction of the cerebral influence, (a destruction not compatible with sensational purposes,) since it is not possible to determine its effects; whereas, in decapitation, the circumstances are easily enumerated and made known: that is, one decapitation is like another; but the force of a blow, the cranial resistance, and the effect, may differ, and give rise to complex, artificial conditions. The stunning of an animal, and its effects on the results of vivisection, cannot therefore, be appreciated with any certainty. No artificial perturbation, that can be avoided, ought to be introduced, especially such as are wholly inappreciable, not to say unnecessary and deceptive.

In ascertaining the functions of an organ, either by the method of vivisection, or by that of morbid action, it must not be forgotten, that the process, though the best the nature of the case admits of, is, nevertheless, to a certain extent, anti-physiological. Hence, the elements introduced by either method must not be fundamentally incompatible with the function sought; their influences and biases must be estimated, and, if it be possible, separated from the resultants properly functional.

If the result sought for be purely normal, or purely pathological, the

artificial condition induced, contributes towards the defeat or the modification of the finality. Many morbid conditions cannot be produced by art. Experiments which sacrifice numerous organs, with the view of ascertaining the function of a given one, may have only an equivocal result; and the more so, if the associate organs destroyed, furnish the conditions essential to the natural manifestations of the organic function which is the object of investigation. A celebrated physiologist says: "We know the peculiar office of the brain, by observing what functions are lost by its removal—the sensorial functions."* Even if it be conceded, that decapitation removes every vestige of sensation and voluntary motion, this would not prove that both these functions belonged exclusively to the brain; for the removal of the heart, or of the lungs, or the inhalation of ether, would equally remove the sensorial functions. On the contrary, however, if these functions can be identified in the smallest degree, in the headless trunk, the experiment is of the most convincing kind, considering the enormous hemorrhage, and the violent, disorganizing character of the operation, incidental to the removal of large masses of bones, muscles, special senses, organs, blood vessels, &c.

If in the progress of discovery, it shall be ascertaind, that the sensorium is diffused throughout the whole nervous system; that it is most active in its peripheral expansions; nevertheless, it must happen, that decapitation and the destruction of the spinal cord, will speedily, or at least ultimately, destroy this peripheral action, by destroying incidentally numerous associated organs, functions, and conditions, essential to life. Physiologists who reduce the nerves to the condition of mere conductors to and from a central, yet unknown, unconscious spot, called the sensorium, in some unrevealed part of the brain, ought not to regard themselves as honoring the nervous system, any more than those who are willing to allow these supposed conductors a share of sensational cognition: seeing how experimenters of their own school, cut out this centre—the brain, including the cerebellum—and push stylets through the centre of the spinal marrow, without, as they say, a loss of sensibility, &c. Add to these facts, the numerous examples of children born without brains, and also, sometimes, with spinal cords disorganized by disease, while the living functions, including sensation and motion, struggled on, in at least some cases, for long periods. The cause of science; the advance of psychology, physiology, and pathology, will not be, in the least, promoted by the exaltation of the centre, and the depression of the circumference. For my own part, judging from experiments

*A. P. W. Philip, M. D., Inquiry, 104, Lond., 1817.

ranging from the cold-blooded to the hottest-blooded animals—from the alligator to the common fowl—I am constrained to say, that after decapitation, the sensational phenomena and voluntary motion are far more strongly indicated in the headless body, than in the separated head. In the fowl, the head dies, or seems to die almost instantly; while the body gives the most violent indications of pain, which, after a time, cease, but may be revived by the application of fire to the feet, &c., as I have proved recently.

The vivisection of the spinal cord, with the view of ascertaining the functions of its roots, is, from its disorganizing nature as a physiological process, alike difficult in execution, and, as the standard for determining the theory of the double functions of the nerves, doubtful in import. The operation is tedious, deep, bloody, painful, protracted, modifying, paramount. Skin, muscles, tendons, cartilages, bones, and other tissues, must not only be divided, but, to some extent, removed. The cord, and roots of the nerves planted in it, must suffer violent and repeated concussions, from the sawing, chiseling, and removing of portions of the vertebræ, little short of disorganization. The spinal dura mater, which attaches itself laterally to the long canal, at the emergence of the nerves, must be divided and drawn aside, to expose the double roots. These operations, together with the opening of the theca; the discharge of its serosity; and exposure to the air, must modify the final result. It is, moreover, difficult to experiment on the anterior roots, without having first destroyed the posterior. If the posterior roots do not generally give equal indications of voluntary motion, or, as physiologists call it, sensation, noticed in experiments on the anterior, may not the reason be sought among these modifying circumstances?

The modifying influence of the disorganizing and paralyzing process necessary to lay bare the posterior roots of the spinal nerves, is illustrated by recent occurrences. From the researches of M. Magendie, made but a few years ago, physiologists concluded, that the cerebro-spinal fluid was necessary to sustain the equilibrium and energy of the muscular system; because the subtraction of that fluid destroyed, as it was assumed, the power of locomotion. But M. Longet has more recently proved, that these effects were due to the *section of the muscles themselves*, in the methods adopted by experimenters. M. L—— found, on making an opening in the dorsal spine of horses, dogs, cats, and rabbits, without dividing the muscles extensively, that this liquid might be removed, without producing such muscular disturbances and functional losses as had been attributed to its removal. (*Compt Rendu*, 1845.)

The vivisection of the spinal cord of living animals, is thus spoken of

by M. Magendie, in the *Journal de Physiologie, etc.:* (see "DOCUMENTS AND DATES.")* "I had long been desirous of making the experiment of dividing, in an animal, the posterior roots of the nerves which arise from the spinal marrow. I had several times made the attempt, without being able to succeed, on account of the difficulty of opening the vertebral canal without injuring the spinal marrow, and, consequently, without destroying, or, at least, seriously injuring the animal." * * *

"It naturally occurred to the mind, to cut the anterior roots, leaving the posterior untouched; but such an enterprise was more easily conceived than executed; how expose the anterior parts of the spinal marrow, without interfering with the posterior roots? I confess, that the thing appeared to me to be impossible." * * *

"I, at first, wished to ascertain if it might not be possible to cut the anterior and posterior roots of the spinal nerves without opening the great canal of the vertebral dura mater."

* * * "The experiment is much longer and more laborious than the preceding one, in which the great canal of the spinal dura mater is opened. I do not think that this mode of making the experiment should be followed in preference to the first." * * *

The following summary of M. Magendie's experiments and conclusions, is taken from the work already cited. "The following are the results of my observations: in pinching, pulling, and pricking these [the posterior] roots, the animal gives signs of pain; but it is not to be compared in intensity, with that which occurs if the spinal marrow be only slightly touched at the part where these roots arise. Nearly every time that these posterior roots are thus excited, contractions are produced in the muscles to which the nerves are distributed; these contractions, however, are but slightly marked, and infinitely weaker than if the spinal marrow itself be touched. If one of the posterior bundles of roots be cut at once, a general movement is produced in the member to which the bundle goes. I have repeated the same experiments on the anterior bundles, and I have obtained analogous results in an inverse sense; for the contractions excited by pinching, pricking, &c., are extremely strong, and even convulsive, whilst the signs of sensibilty are scarcely visible. These facts are confirmative of those already announced; only, they seem to establish, that sensation does belong exclusively to the posterior roots, any more than motion to the anterior. * * * I had still to make another kind of experiment on the spinal roots—that of galvanism. By its means, I accordingly excited

*London: 1839. p. 87, *et seq.* Translated by the Editor.

these parts, first leaving them in their ordinary state, and afterwards cutting them at their spinal extremities, to place them upon an isolating body. In these various cases, I obtained contractions from each sort of roots; but those which followed the excitation of the anterior roots, were, in general, much stronger and more complete than those which took place when the electric current operated upon the posterior." * * *

"I repeated the experiments, after having separated the roots from the spinal marrow; and I ought to say, that, with the exception of two animals, in which I saw contractions upon pinching and pulling the anterior and posterior bundles, in all the rest I did not observe any sensible effect from the irritation of the anterior or posterior roots thus separated from the spinal marrow." * * *

"The central parts of the spinal marrow may be touched, torn, even, we may say, with impunity, always taking the precaution necessary to avoid touching the surrounding medullary substance. I have several times plunged stylets through almost the whole length of the spinal marrow, without either the motions or the sensibility of the animal appearing to be diminished. * * * Lesions of the cerebellum, do not cause loss of sensibility. The subtraction of the hemispheres does not necessarily cause the loss of motion. * * * Total ablations of the cerebellum do not cause a loss of sensibility. The cerebellum appears necessary to the integrity of movements forward."

Sir Charles Bell, to whom the discovery of the double functions of the nerves has been attributed, (though unjustly,*) thus speaks† of the vivisection of their spinal roots: "To expose these nerves near their origin, requires the operator to cut deep, to break up the bones, and to divide the bloodvessels. All such experiments are much better omitted; they never can lead to satisfactory conclusions." * * * "I have found it difficult to make the experiment without injuring both." * * * When the anterior roots singly, or the whole spinal nerve was pinched by the forceps, or pricked by the scissors, an evident motion was produced on the muscles, not only perceptible to the eye, but when the third or fourth dorsal nerve was touched, the whole scapula moved in the hands of the assistant." * * * * * * "Anatomy is," as Bell affirms, "better adapted for discovery than experiment." Although it is, to me, inconceivable how Sir Charles Bell's discovery could have been made

*I have already proved that Mr. Alex. Walker preceded Bell, in the so called discovery of the double function of the nerves; the unanimity of the British and American writers to the contrary notwithstanding. If any more evidence be wanted to establish this, my protest, against one of the greatest historical falsehoods of the century, I am prepared to give it, without delay.

†Bell's Nerv. Syst.: *passim.*

without experiment, yet he holds the following language: "experiments have never been the means of discovery; and a survey of what has been attempted of late years in physiology will prove, that the opening of living animals has done more to perpetuate error than to confirm the just views taken from the study of anatomy and natural motions." * * * In a review of my former papers, the results have been considered as a further proof in favor of experiments. They are, on the contrary, deductions from anatomy; and I have had recourse to experiments, not to form my own opinions, but to impress them upon others. It must be my apology, that my utmost efforts of persuasion were lost, while I urged my statements on the grounds of anatomy alone. I have made few experiments; they have been simple, and easily performed; and I hope are decisive." * * * "In the demonstration of the nerves I had recourse to their origins to find out their uses. I found that injury done to the anterior portion of the spinal marrow convulsed the animal more certainly than injury to the posterior portion; but I found it difficult to make the experiment without injuring both portions."

"The motions," says Dr. Carpenter, "excited by irritating the posterior root, are entirely dependent upon its connection with the spinal cord, and upon the integrity of the anterior roots, and of the trunks into which they enter. It is evident, therefore, that excitation of the posterior roots does not act immediately upon the muscles, through the trunk of the nerve, which they contribute to form; but that it excites a motor impulse in the spinal cord, which is propagated through the anterior roots to the periphery of the system." (Phys.)

Had Messrs. Magendie, Bell, and other vivisectors, extended their experiments from the roots of the nerves towards their distributions, with, or without having first separated them from the spinal cord, they would have found, not a total loss of muscular motion from the division of the anterior roots, but a marked increase of twitching, etc., on compressing the more distal portions of the nerves. The roots being very soft, a pressure, unless extremely delicate, will, perhaps, give only one, or, at least, a very few twitchings, which never can be renewed, without selecting a new distal part. Hence, Mr. Magendie never saw, but in two animals, motions excited, after the roots had been separated from their implantations in the cord. Sir Charles Bell refers to Mr. C. Hawkins, to prove that the pinching of the spinal nerves, at their origins, caused "an evident motion, perceptible to the eye, etc." This is true; but not the whole truth.

Messrs. Kirke and Paget say that, "where the end of the *distal* portion of the divided nerve is irritated, no effect appears." (Phys. 289.)

Is this an error of the press? When a nerve is divided, as above mentioned, I have invariably found that no effect follows pinching or puncture on the proximal side, even though the nerve may be connected with the spinal marrow—with, and without that connection, the distal end will respond to an irritant, properly applied, for several days, in the alligator.

The motions which may be elicited after the destruction of the brain, spinal marrow, and the sympathetic, and, even in amputated limbs, are more or less suggestive of the theory of galvanic action. But they are neither homological, nor analogical. It is true, that a certain degree of compression, whether by a good or bad electrical conductor, causes a quick motion, or twitch, like that from a weak galvanic shock. But here all analogy ceases. There is no galvanic battery by which to generate this force; which is, indeed, altogether physiological. Besides, there is not one shock, and one contraction, but many, of an intermitting kind. These approximate the slighter kinds of convulsive movements in chorea, fits, cramps, subsultus, delirium tremens, and in some forms of death, but most of all, certain motions, which, sometimes, take place in sleep, and after death from cholera, with, and without, an irritant. Very recently, while making vivisections of several different kinds of animals, and while my mind was strongly directed to this subject, the following circumstances were observed: a man was asleep in a hotel—an individual who was present, wishing to amuse himself, applied a feather to different parts of the body of the sleeping man, which, in several instances, produced motions similar to those above described. In February, 1851, by the merest accident, I observed in a person in profound sleep, that pressure in the course of the muscle which extends the four outer toes, caused slight twitchings, exactly similar to those I had observed in the separated limbs of the alligator. The pressure, and the twitchings, were repeated from time to time, without awaking the individual.

But the most perfect type of these very peculiar and very limited sorts of contraction, originating spontaneously, and continuing, sometimes, for hours, is that which I have seen in private practice, as well as in the hospital, in the fingers and toes of the human subject, after death from cholera. In one case, witnessed by several physicians, as well as by myself, the contractions were quite different, having assumed the appearance of voluntary actions, as manifested in flexing, and extending the limbs, and forcibly clenching the fists. I first observed these slighter, muscular, to and fro oscillations, in 1833.

During eleven years, ending in 1851, many hundred experiments

have been made on the human subject, and recorded in numerous manuscript volumes, clearly proving that functional contractions, as flexion of the arm, can be exited by slight blows over the biceps—after, as well as before, amputation—after, as well as before, the division of every nerve—after, as well as before, the division of every muscle, except those immediately appropriated to the particular action sought for—after, as well as before, temporary exhaustions from repeated flexions, by which, in many cases, weights in the palm had been raised from the floor through the vertical, and thence carried to the breast—after, as well as before, the *rigor mortis**—provided, however, the muscular organs be not contused or disorganized.

This force resides alike in every part of the muscle. Take a piece of thin plank, one inch wide—strike the biceps, at intervals, exactly in the same place, in a transverse manner; the forearm will be raised, (if contractility be present,) from one to fifty times, but will at length be exhausted, at least for a time—instead of waiting for the regeneration of the force, strike with a piece of plank, twice as wide as the first, and contractions will follow, as before, and so proceed, until the whole length of the muscle has been percussed, and temporarily, or permanently, exhausted.

These motions from the direct percussion of the human muscles are as perfect, so far as simple flexion is concerned, as the voluntary motions themselves, though, of course, the latter may be combined, varied, retarded, accelerated, and perpetuated in a thousand different ways, unknown in the former.

The twitching motions from pinching the nerves, described in the above mentioned vivisections, are almost infinitely removed from those following percussion of the muscles, even though deprived of all the visible nervous trunks, and all connections with the nervous centres. Nevertheless, it must be conceded, that these twitchings, as far as they go, in the absence of all experiments directly on the muscles themselves, seem to favor the views of those physiologists who ascribe motion as well as sensation to the nerves. The truth appears to be this:—there are several ways or causes, by which the muscles may be excited. Thus compression of the nerve produces the minimum—the percussion of the muscles, the maximum of motion. The latter is not only incomparably greater, but approximates the natural functions, while the other does not. In the recently dead human subject, the removal of the nerves, it may be

*The only opinion concerning contractility that I have found it necessary to modify, is this: the *rigor mortis* is not incompatible with the contractile force, though the former diminishes or prevents the full action of the latter.

repeated, does not diminish the muscular contraction, in degree, or in duration. The twitching of the muscle from compression of the nerve, is a curious, and an unexplained fact, which, however, does not disprove the doctrine that the muscles have a force inherent in themselves. That the nerves, in addition to their great sensational functions, may generate a force auxiliary to the muscular force, is not improbable :—the blood may contribute in like manner, since its own motions, particularly in the capillary system, seem to indicate an inherent force, which may be called vital, as it rises above any known mechanical force.

The nerves are supposed to be the cause, and not simply the essential condition of motion, because their division prevents it.* By parallel arguments the blood can be proved to be the cause, and not simply an essential condition of muscular motion, because its arrestation is followed by an instantaneous, general, and complete loss of motion and sensation. Dr. Carpenter says : "The contractility of the muscle is impaired or altogether extinguished, when the flow of the blood into it is arrested." * * * "If the circulation through the brain be suspended but for an instant, insensibility and loss of voluntary power supervene, and continue until it is restored. This was shown by the following experiment of Sir A. Cooper's. After having tied both carotid arteries in a dog, he compressed the vertebral trunks, and immediate insensibility came on, the animal at the same time falling powerless. As soon as the blood was re-admitted to the brain, the animal recovered its consciousness and voluntary power, and stood on its legs again. In syncope, the circulation through the spinal cord is weakened, a general cessation—not merely of muscular movement—but of all power of exciting it, is the immediate result. No sooner, however, is the circulation fully re-established, than the power of the nervous centres is restored. Dimin-

*How much vain theory has been suggested, from the simple experiment of loss of power in consequence of tying a nerve; and yet it was not the compression of the tubes of the nerve, but the obstruction of blood-vessels, which produced the effect. (Bell's Anat. and Phys. Edit. 1834. i. 54.) Such is Sir Charles Bell's latest opinion.

When the very seat of perception is found not to be sensible, it leads us to consider on what the varieties of sensation depend. We see that sensibility is not an accidental, nor a necessary consequencc of the structure of a nerve, or the presence of the nervous matter, nor even the communication of that nerve with the brain. It is obvious, that the sensibility results from the particular part of the brain which is affected by the nerve. (Bell's Anat. and Phys. Edit. 1834. i. 55.) Reader, read, and re-read this statement of Sir Charles Bell. Anatomy, the nervous matter—the functional intuitions of sense—all subjectivity or individual consciousness, and even all the brain, except the unknown "particular part," are, like poor Cordelia's portion of King Lear's dominions, "Nothing!"

"*Lear.* Nothing can come of nothing; speak again."

ished circulation at the origins of the afferent nerves is shown in the deficient impressibility of the nerves of the part affected. A complete stagnation, (of the capillaries,) produced complete insensibility." (Phys.)

Now these facts, (and every practical physician must have seen many equally striking,) show, that the non-circulation of the blood, produces a loss of motion and sensation, rivalling in instantaneousness and completeness the division of the nerves, which latter operation constitutes the *experimentum crucis* of neurological dynamists. Another method of suspending, temporarily, or of destroying even permanently, sensation and motion, is that of anæsthesia, or the inhalation of ether and chloroform. Local anæsthesia, as that of a finger, is more explicable by the assumption of a local sensory and motory function in the part affected, than by referring the whole to the posterior and anterior roots exclusively. In truth, as already stated, there are various methods both of exciting, and suspending muscular motions without any known causative relation to the nerves.

The nerve, the blood, respiration, oxygen, and the like, furnish the conditions essential to the voluntary action of the muscles—as temperature, moisture, and earth, furnish the essential conditions by which the acorn becomes an oak. On the contrary, the loss of motion and sensation in many, if not most cases, is not preceded by any known lesion whatever, in either the motiferous or sensiferous nerves. Indeed, the pathological method of investigating the double functions of the nerves, is unfavorable to the latter hypothesis. Of the vast catalogue of nervous diseases affecting motion and sensation, each of which would be an illustrative experiment by the hand of nature, not one is founded on pathological anatomy, conformably to this hypothesis; that is to say, not one has been proved to have been invariably preceded by well marked lesions of either the posterior or anterior roots, or the sensiferous, or motiferous portions of the nervous system. For example, Tetanus, Hydrophobia, Epilepsy, Convulsions, Spasms, Palsy, etc., cannot be satisfactorily referred to lesions of either portion of this system, to which they are supposed to belong; for example, in a Palsy, with a loss of motion and sensation, neither the motiferous nor the sensiferous roots present well marked alterations: again, in Tetanus, a disease which is taken as a type of motiferous diseases, no constant, or even frequent, morbid change has been found in the nerves called motiferous, to the exclusion of the other nerves.

Dr. Carpenter, in his exposition of the functions of the spinal cord by means of what he terms "pathological applications," says: "The power of the whole spinal system is capable of being morbidly dimin-

ished or increased"—"increased in Tetanus, Epilepsy, Hysteria, Hydrophobia, (which, by the way, he calls a disease of the blood,) by Strychnine, by Aloes, and by Cantharides." (Phys. ¶ 400, 401.) How true soever this assertion may be, it does not prove that this increase or diminution can be ascribed with absolute certainty to either class of roots. To say, that because the power of the muscles (in Tetanus) is morbidly increased, therefore the power of the anterior roots is morbidly increased, is a *non sequitur*. If strychnine, cantharides, and aloes, act specifically on the cord, or the anterior or posterior roots—if the numerous diseases which are said to have their seat in these structures, produce, or result from morbid alterations analogous to other maladies—alterations, such as redness, vascularity, hypertrophy, atrophy, induration, softening, and ulceration, anatomists have not been able to find them, after innumerable examinations of dead bodies, nor have descriptions of them appeared in books of pathological anatomy, so as to connect diseases of sensation and motion with any recognized lesions in the sensiferous and motiferous nerves, roots, tracts, or central sensorium.

If there be no anatomical proof, (as is admitted by all,) showing that the sensiferous and motiferous nerves can be distinguished from each other only at their spinal origins*—if the numerous diseases which have been ascribed to each class of nerves, produce no lesions of their roots discoverable by the morbid anatomist; then no proof remains but that derived from experiments on the roots. Passing by the destructive nature of experiments upon the spinal centre—saying nothing of the induced, unnatural condition at the very moment that the operator is in-

*"With this difference in the functions of the nerves, there is no apparent difference in the structure of the nerve-fibres by which it might be explained.—Of the laws of action peculiar to nerves of sensation and motion respectively, many can be ascertained only by experiments on the roots of the nerves. For it is only at their origin that the nerves of sensation and motion are distinct.—No nerve-fibre can convey more than one kind of impression.—All nerve-fibres are mere *conductors* of impressions.—Impressions are only *conducted*—in the brain alone may be *perceived*." (Messrs. Kirke and Paget. Phys. 286, 289, 288, 294.) If there be no anatomical distinction between the motiferous and sensiferous nerves, what becomes of Sir Charles Bell's discovery, which he himself declares is based wholly on anatomy?

The doctrine of an exclusive sensorium—one restricted wholly to a spot in the brain, contradicts not only the universal intuition or experience of mankind, but is self-contradictory; for sensation can have no existence in time and space, only so far as it is *felt*; it exists only at the time when, and the place where, it is cognized. At all other times and places, it has no existence whatever. The pain of a whitlow in the finger is felt there, and not in the optic thalami, or crus cerebri. The very essence of a sensation consists in the feeling of it, and when it is not felt, it is not. The only method by which sensation is known, is that of consciousness, which is stronger than any other evidence.

tent upon seeking just the contrary, that is, the pure, natural function, it is sufficient to consider that there is no standard or criterion by which the phenomena in question can be interpreted, so as to mean nothing more—nothing less than the laws which have been drawn from them by the advocates of the double, or the four-fold functions of the nerves. Waiving the question whether both of these functions belong exclusively to one, two, or four different kinds of nerves, the true question is this: do the experiments prove the theory? Is not the fundamental principle of interpretation, an assumption? erroneous? By what analogy—by what natural language of animals, can it be proved, that the motions excited by irritating the anterior roots are not really sensiferous? As a dumb beast has no other means of making known its sufferings, (whether in the posterior or anterior roots,) except by signs, that is, motions, such as the experimenters describe as convulsive, etc.; the latter, therefore, so far from excluding sensation, indicate its presence. How true soever the motiferous theory of the anterior roots may be, these experiments do not clearly prove it. They do not show motion in the abstract—motion in the concrete; they do not demonstrate that these roots originate or convey all the forces to the exclusion of the muscular system, and the posterior roots. They do not prove that in the living animal, the anterior, do not partake with the posterior roots in sensationalism.

The almost uniform prelude to a vivisection, has been, (to use the language of the experimenters,) a blow upon the occiput, so as to deprive the animal of *sensibility*. The motive that impels the vivisector to his repulsive task, is, or ought to be, as praiseworthy as any that can sway the human mind, namely, the obtainment of knowledge for the purpose of lessening the ills of humanity. But, an occipital *coup de grâce*, depriving an animal of sensibility, in whole or in part, in order to experiment on its *sensiferous* nerves, is as bad in logic, as it is in true benevolence, since it defeats the legitimate end, which is the only justification of the means. Physiology cannot be promoted by *piæ fraudes*.

The high, paramount, sensory function of the nervous system, renders its claim to exclusive motiferous jurisdiction, even over the muscular system, a somewhat doubtful duality, and little in accordance with philosophical analogy. The dynamical adaptions for flexion, extension, as cord, levers, joints, and the like, so evident in the muscular and osseous systems, nowhere appear in the nervous.

Leibnitz, "whose mind was cast in a gigantic mould," based his whole philosophy upon this single axiom, namely, "that one substance

cannot receive from any other the power of acting, but the whole force is pre-existent in itself."

The principle, says Mr. Morrell, has long been acknowledged by philosophers, that "two substances entirely differing from each other can have no mutual influence whatever."

This view may be too strongly stated, to apply invariably in dynamical physiology, but not more so than that presented in Condillac's philosophy, where the entire nature of man is supposed to be but a mass of nerves: "*Les nerfs voilà tout l'homme.*"

In animal dynamics, as in every other department of physiology, the luminous principle of adaptation is of the highest value, and must not be forsaken for experiments, which, as experiments, create, or influence results. Nothing of dynamical adaptation—every thing like inadaptation, is evident in the nervous tissues, viewed as the organs of contractility or motion.*

Broussais contends, (Path. 64, 104,) "that contractility is the sole inherent property of the fibre," and that "sensibility is only one of the results of contractility. On the other hand, Dr. Carpenter maintains, that even "the will cannot exert any direct or immediate power over the muscles." (Phys. ¶ 495.) That the will can exert an immediate control over the motory organs, appears, to me, a truth of which every healthy human being, unbiassed by theories, is, or ought to be as conscious as he is of his own existence, whether he be acquainted with the exact anatomy of these organs, or not. It is this consciousness of the possession of an immediate, inherent, inward force, which is the fundamental type under which all voluntary forces are viewed, and without it there is little doubt that we should have been unable to form any notion of the involuntary and physical forces, which give to the whole universe a near approximation to vitality.

The doctrine of a diffused sensorium, is an intuitive conviction; based on consciousness, at least it is such, with all not educated in a different belief. No one can appeal to consciousness for the proof that a certain unknown spot in the brain possesses the faculty of feeling by means of one particular sort of nerves, which serve as the mere conductors of material, or immaterial impressions, to be felt only in the centre, but in no degree in the trunks, nor in the peripheral expansion,

*Touch, in the headless alligator, responds in a normal manner, that is, according to all that is known of that fundamental sense, under excitation. Like the deaf, dumb and blind, it reads, (so to speak,) only by mechanical contact. It cannot know, will, or act, in advance of an impression, any more than it can smell, taste, see, or hear, without the special organ devoted to the function.

of the nerves, themselves. The rejection of a diffused sensorium, and the general admission of one exclusively central, are, probably, in a considerable degree owing to the psychological, or rather the theoretical difficulties with which education has environed these views, in assuming them to be incompatible with the supposed oneness of life, personal identity, the union of volition and sensation. A duality or a triplicity in any of these would seem to conflict with long cherished theories. Well established facts, cannot be invalidated by any difficulties whatever. Physiology, resting as it does in a great degree on vivisection of the inferior animals* (none having been made on man,) can have no existence, as an experimental science, without the evidence of analogy, which is, indeed, the point of departure for the systematic writers on this science as it now stands. "In fact it may be said almost without qualification, that "Wisdom consists in the ready and accurate perception of analogies."†

That an alligator can be divided into at least three parts, each possessing for a time an independent sensation and volition, is a truth based on experiment made in a class of animals (the cold blooded) much used in vivisection—a truth confirmed analogically, by natural history: the late H. Milne Edwards, Prof. of Natural History, Paris, says, "If an earth worm be cut transversely into two, three, ten or twenty pieces. each of its fragments may continue to live as a whole, and to constitute a new individual." (Anat. and Phys.)

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*It is remarkable that the celebrated Dr. Carpenter, of England, in his Physiology on Man, (¶875.) advances the following proposition, namely, "Experiments on the nature of this (the nervous) function, are best made upon the *cold-blooded* animals; as their general functions are less disturbed by the effects of severe injuries of the nervous system than those of birds and mammals."

Certain critics, who offer no arguments, much less experiments to prove the four-fold anatomy and the four-fold functions of the nervous system, seem most happy-most fully protected against error, so long as their faith conforms to that of "distinguished European physiologists." As the latter, however, are beginning to see and to abandon their errors, the former ought not to delay their conversions too long. Dr. Carpenter, in the last edition of his elaborate work on physiology, says "It has been maintained by Dr. Marshall Hall, to whom physiologists are indebted for having *recalled* their attention to the reflex function of the spinal cord which had been *previously described* by Unzer and Prochaska, that the fibres which minister to this function are '*physiologically distinct*' from those which are the channels of sensation and of voluntary movements; the former being regarded by him, as having their centre in the '*true spinal cord*,' and the latter in the brain. But it is open to so many objections, that it has not been generally received by those physiologists who have most carefully studied the nervous system; and it now seems possible to give an explanation of the phenomena, which is at the same time more simple and more conformable to analogy."

†Arch. Bp. Whately, Rhet. 104.

Cuvier asserts, (D'Anat. Compar.)that there are among invertebrated animals, some which after division into two or more parts, constitute immediately two or more individuals, each of which possesses independent sensation and volition. Il y a des animaux invertébrés qui, étant coupés en deux ou plusieurs morceaux, forment à l'instant même deux ou plusieurs individus qui ont chacun leur système de sensation et leur volonté propre : These animals may be divided *ad infinitum*, and yet each fragment will possess a distinct personal identity—the subjective element—The Me:—peuvent être divisés, pour ainsi dire, à l'infini, et chacun de leurs fragments devient un individu doué de son moi particulier.

The unity or indivisibility of sensation is not inferable from the smallness of the sensorium, as the smallest part of the brain is as divisible, as the entire nervous mass.

The history of science shows but too clearly, that, while nature has always been teaching truths only, prejudices of education have biased the minds of individuals, nay of entire nations,—so that the reality of matter itself has been called in question, and great errors have received a sanction almost unanimous and universal. It is sufficient to mention in this place, the long reign of the representational or ideal system, in opposition to that of the *immediacy* of knowledge. In the mental and speculative sciences, ideas are no longer regarded as entities, at once the only intermedia, and the sole objects of cognition, so that according to this theory, things are not themselves objects of sensation, but their representational impressions only! In physiology the representational system still prevails,—the word idea being replaced by the word impression. Sensational cognition, instead of being regarded as intuitive, direct, and immediate, is assumed to be wholly intermediate, by means of coducting tracts, transmitted impressions, and a central sensorium. That these transmitted impressions are entities, is virtually asserted in assigning to them a special, material nerve, along which they travel to the centre where they imprint themselves.

"Dr. Robert Hook makes ideas to be material substances. The soul, he thinks, may fabricate some hundreds in a day, and that as they are framed, they are pushed farther off from the centre of the brain, where the soul resides. By this means they make a continued chain coiled up in the brain, the first end of which is farthest removed from the centre or seat of the soul; and the other end is always at the centre, being the last idea formed, which is always present the moment when considered: and therefore, according as there is a greater number of ideas between the present sensation or thought in the centre and any other,

the soul is apprehensive of a larger portion of time interposed." (Reid's Essays.) Is there any important part of this statement, which is not expressed or implied by the prevailing doctrine of transmission, which assumes, that there is independent of the external impression, a material, travelling impression (not a metaphor) which pursues a definite material route or structure, to make a material imprint on a material sensorium.

Dr. Hartley, in his work "On Man," (London, 1748,) speaks of both sensory and motory nerves.

"Those sensory vibrations which are excited in the external organs and ascend towards the brain, when they arrive in their ascent at the origin of the motory nerves, descend from the brain into the whole system of the motory nerves."

He attemps to account for the inferiority of the intellectual faculties of brutes compared with man, by the fact that "their brain is proportionally smaller, and hence cannot contain so many nor so great a variety of miniature impressions,—miniatures of external impressions." He maintains that the nervous system of brutes "has more callosity and fixedness in its dispositions to vibrate, than in man." "The brains of young brute animals will therefore be sooner able to retain miniatures than those of children."

Sensation is not produced by the intermediary agents called transmitted impressions or ideas, but is an intuitively felt relation, between the ME* and the not ME.—the subjective and the objective, founded on

*Before proceding further, the following definitions may be necessary:—*Definitions of Subjectivity and objectivity*:—These terms, from their perspicuity, precision, and comprehensiveness, are daily growing into favor in scientific researches, particularly among German writers. As some individuals may object to them, as I once did, and as others may not understand them, it may be proper to define them. These definitions are not taken from dictionaries, but are, in a great degree, results produced in my own mind, from the perusal of the French and English translations of German authors who excell in speculative science. Kant, in my humble opinion, has had no superior from Aristotle to the present time.

Subjective and *objective*.—Sensation, is, in its own nature, subjective; but it may originate either subjectively, that is, in the mind, or objectively, that is from impressions derived from the outward world. The one is psychical; the other is physical or sensuous in origin, but the effect is the same in both, namely, a state of feeling or conscious excitation being induced.

Whatsoever constitutes self or the ME, the knowing, willing, feeling, conscious entity or condition, is the subjective. All the residue of nature, all that is not the ME, is objective. In a certain sense, however, the mind, when directed to itself and its conscious faculties and conditions, becomes objective to itself—a peculiar prerogative—a combination of subject, and object.

The subjectivity or subjective symptoms of a patient, consist in whatsoever is proper to his consciousness, or feelings—the residue of his symptoms, observed by the physician, are objective.

Whenever a conscious relation is established between the subjective and the

immediacy and intuition, and not on representationalism, being like every other ultimate and self evident fact, incapable of any proof stronger than that which is inherent in itself. All attempts to explain this felt relation, tend but to make it more obscure. That change or sensational relation that takes place between the object seen, and the subject that sees, cannot be defined, although the phenomema, the conditions, and laws according to which the latter conform, contribute to illustrate or rather constitute the science of optics. When an object is touched, the result is a felt relation directly between the subject and object, not between the subject and a mere representation of the object. If the mind cannot know things, but their representations or impressions only, Berkley, was right in affirming, that as the mind could know these alone, there could be no valid proof of the reality of a material world.

The present representational system of physiology, besides subject, object, nerve and impression, expresses or implies, four kinds of nerves, four kinds of locomotive impressions, an encephalic sensorial spot, an excito-motory centre, not to name a ganglionic one—complications found in books, not in nature—in maps, not in intuition.

The present system of representationalism in physiology, is infinitely more complex and obscure than the ancient system of ideas or phantasms, advocated by Aristotle and his followers.

Fearing that the above experiments and speculations, may seem inaccordant with received views in psychology, as well as in physiology, it may be proper to add a few words concerning their fundamental relations, differences and tendencies.

Psychology, in its highest functional modality, unity, and inherent ontological qualities and relations (*substantia et accidens*) is but little amenable to the materializing process of physiology. Whether psychological life is from its inherent constitution capable of a separate and perpetual existence, independently of the sensuous life, is a problem which mere science is unable to solve. The dissection of the inferior animals can neither prove, nor disprove it. Psychology does not rest wholly upon the sensuous, nor upon the transcendental. It derives many of its fundamental truths from its own proper nature; its inward reality, its subjective element, or consciousness. In its sub-

objective, this *felt relation*, is, properly, a sensation—an intuition, immediate, not by means of strolling, representational, transmitted impressions, but by one or more direct impressions on the organ or tissue that is excited or impressed. The science of sensation has nothing to do in explaining the sensational intuition itself. The circumstances, conditions, and laws under which sensation takes place, are susceptible of explanation, as in optics, accoustics, &c.

jectivity it finds its validity, rather than in the objective processes, as those of vivisection, pathological alterations, and outward nature. The one science is essentially subjective; the other is chiefly objective; though the latter, in some of its highest generalizations, derives its fundamental types from the former—The Me.

The common axiom, namely, that there is nothing in the mind which was not first in the senses, is an error due to the biases which exist in favor of an entirely objective philosophy. The mind itself did not thus pass through the senses—the understanding or cognizing faculty existed prior to sensuous transmission and empirical cognition; it existed for itself and in itself, even before its own subjective activity. The psychological entity, and its primary faculties, are not created, but developed by objective nature. The sensuous is the occasion, condition, means, not the cause, much less the essence of the mind. The mind is not a blank leaf, (*tabula rasa*) upon which anything may be written without limit, in the absence of innate faculties, by all possible chances, and contingencies. The mind derives from itself, and not from experimental science, not a few truths which the latter never could discover: such as the intuitions of eternal duration, the infinity of space, &c. The negation or non-existence of these, are, also, intuitions, not derived from experience. Psychology and physiology differ almost as much as the subjective, and the objective. Their nearest points of contact, and their greatest convergency appear in their dynamical relations and in whatsoever relates to the *scientia scientiarum.*

As mental ontology does not come within the pale of physiology—as the mind is regarded as immaterial, having laws peculiar to itself, it is evident that nothing in the experiments, as above reported can, conflict with laws purely psychological.

The following cases, not less than vivisection, will illustrate many of the fore-going principles.

The case of P. P. Gage, a rock blaster, reported at great length by Dr. Harlow, and attested by many numerous professional and non-professional witnesses, may be thus summed up: by the accidental explosion of a quantity of gun-powder intended to blast a rock, an iron crow bar weighing 13¼ lbs., was driven under the zygomatic arch of the left side or cheek, upwards, diagonally through the brain, making a hole at its emergence into the air, three and a half inches in diameter at the junction of the coronal and saggital sutures. The man fell; but soon got up quite rational and self possessed; mounted a cart; sat erect unassisted; reached his hotel; mounted the stairs; sat down in the piazza, and was under the doctor's hands in twenty-

five minutes after the accident. Except the loss of sight in the left eye, and an attack of fever, coma, &c., which occured some time after the injury which happened in 1848; this man has enjoyed health of body and mind, up to the time of the report, in the midsummer of 1850.

A case more recently reported in the Western Medico-Chirurgical Journal, is still more extraordinary, since it shows as proved by a post mortem examination, that a large charge of buck-shot accidentally discharged, entered the skull above the ear, traversed the brain, and lodged against the skull and in the tissue of dura mater of the opposite side, causing extensive fractures and injuries extending to the cerebellum, with the loss of an ordinary tea-cup full of brain. The man lived several days in the perfect enjoyment of all his senses and faculties, until just before his death.

If such injuries can be borne for days, and even years, without impairing sensation, voluntary motion, and conciousness, surely, vivisectors speak hypothetically, when they assert that a blow on the back of the head, will keep all these functions in abeyance while they are performing tedious operations on an animal having, for aught that can be known to the contrary, the whole, or but five, ten, or fifty per cent. of life; or perhaps, none at all.

In both of these cases the fundamental principle of Phrenology is invalidated, namely, "that not a single instance (of injury of the brain) is recorded in which this destruction of both organs has occurred, while the alledged manifestations existed".* In the crow-bar case, a hole of nearly one foot in circumference, in the median line of the cranial summit, must have destroyed several organs for which there are no duplicates, as Benevolence, Veneration and Comparison. In the gun-shot case, the destruction was far more extensive. These facts bear equally against the doctrine of an exclusively central sensorium.

If vivisections, and traumatic lesions of the brain were insufficient to disprove the doctrine that the brain is the sole seat of all sensation; the fact that *brainless* monsters have enjoyed the nutrition, secretory, calorific, respiratory, circulatory, and sensational functions, is altogether couclusive. In the New York Journal of Medecine, for July, 1850, the Editor, Dr. S. S. Purple, has described "a very perfect specimen of brainless child which enjoyed the full amount of sensibility," together with the functions above mentioned, for two days and a half after its birth; when irritated, it uttered imperfect cries, and would

*Combe, Phrenology, 99, 609.

"have lived longer but for a circumstance over which the writer had no control". * * * From this, and many similar cases, Dr. Purple concludes that, "There is a point in physiology upon which they throw no small degree of light, viz: that of the independent action of the great vital functions, from the large nervous centres."

Experiments, facts, arguments, illustrations, and propositions* have been dispersed through these pages regardless of syllogistic formalities —a method adapted to promote investigation, and prevent, in some degree, foregone conclusions.

Unlike a prisoner at the bar, an innovator has this consolation, namely, that if the present jury shall condemn him, unjustly, he can look with confidence to a future one, which soon, or late, will do him, and itself, justice, by embracing the truth; although, probably, for a time,

"It will be found upon examination,
That Satan has the largest congregation."

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"A hundred cities claimed a Homer dead,
Through which a living Homer begged his bread."

An elegant writer, however, takes a view somewhat different: "An author," says D'Israeli, "must consider himself as an arrow shot into the world; his impulse must be stronger than the current of air that carries him on—else he falls." The plenitude of an author's complaints must appear, to such as will not accept his contributions, as the veriest of all platitudes. A medical critic, in a foreign Review, says, upon this topic, "that it is the invariable rule, to invoke the over-worked shades of Harvey and Galileo as illustrations."

New-Orleans, June, 1851.

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*The present investigation necessarily excludes all examination of the ganglionic nervous system of organic life, because it has been assumed, that this system is independent of the cerebro-spinal, in function, as well as in anatomy. Bichat declares, that even "each ganglion is a distinct centre, independent of the others in its action;" and most authors allow but little, if any sensibility and voluntary motion to this portion of the nervous system.